

# MICE SciFi Tracker update

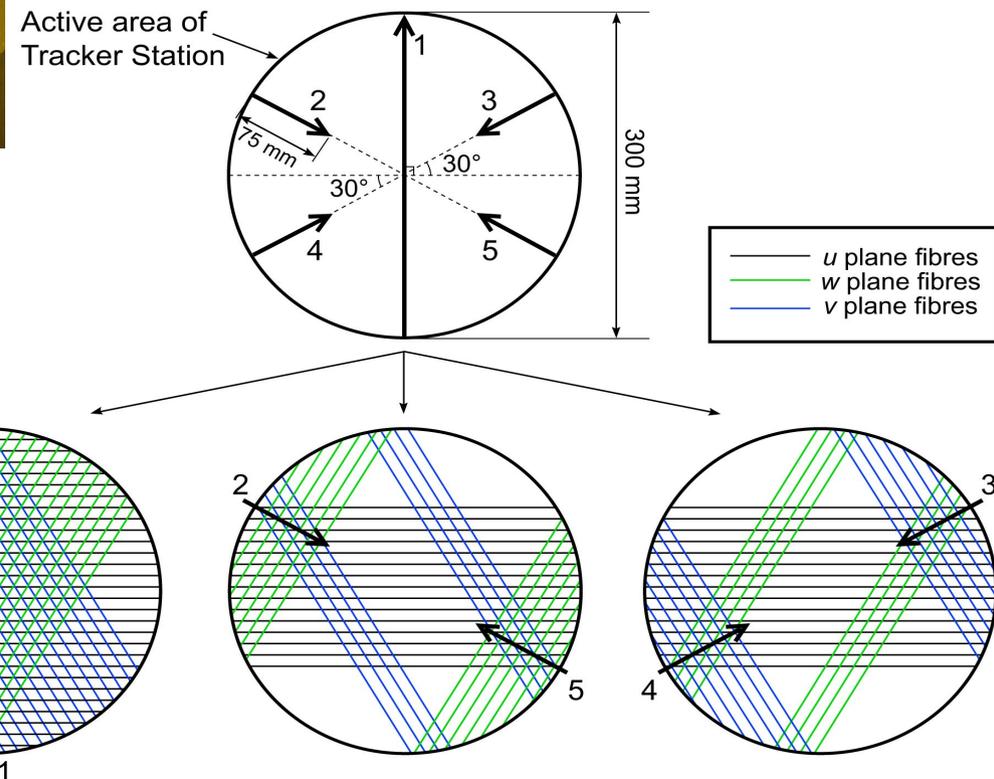
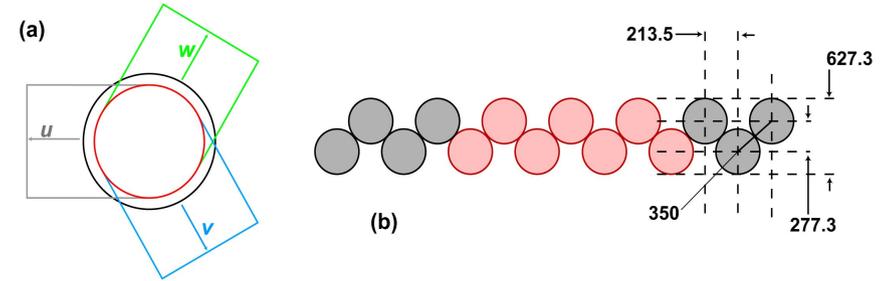
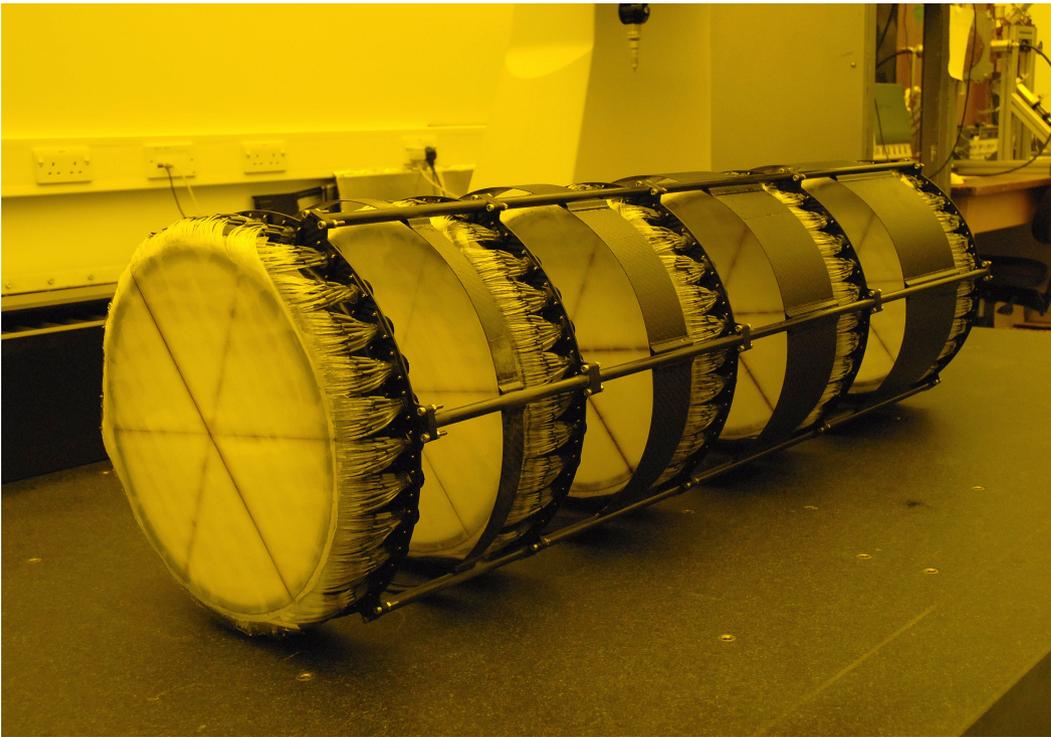
D Adey on behalf of the MICE Tracker Group

MAP Spring Workshop

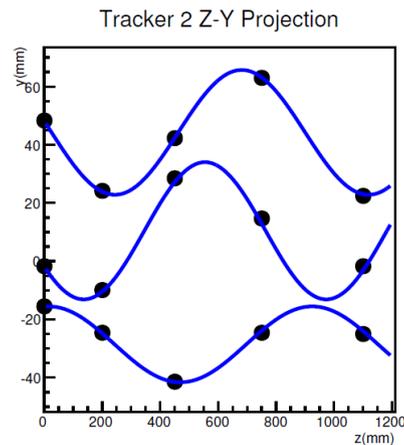
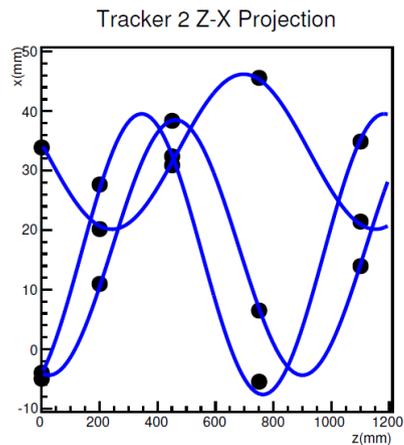
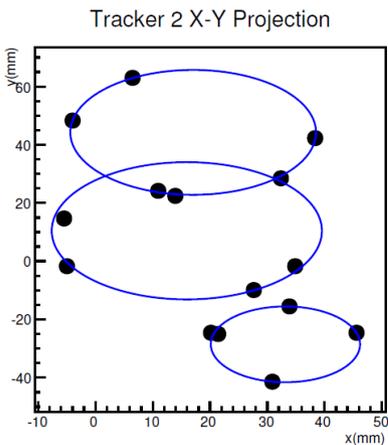
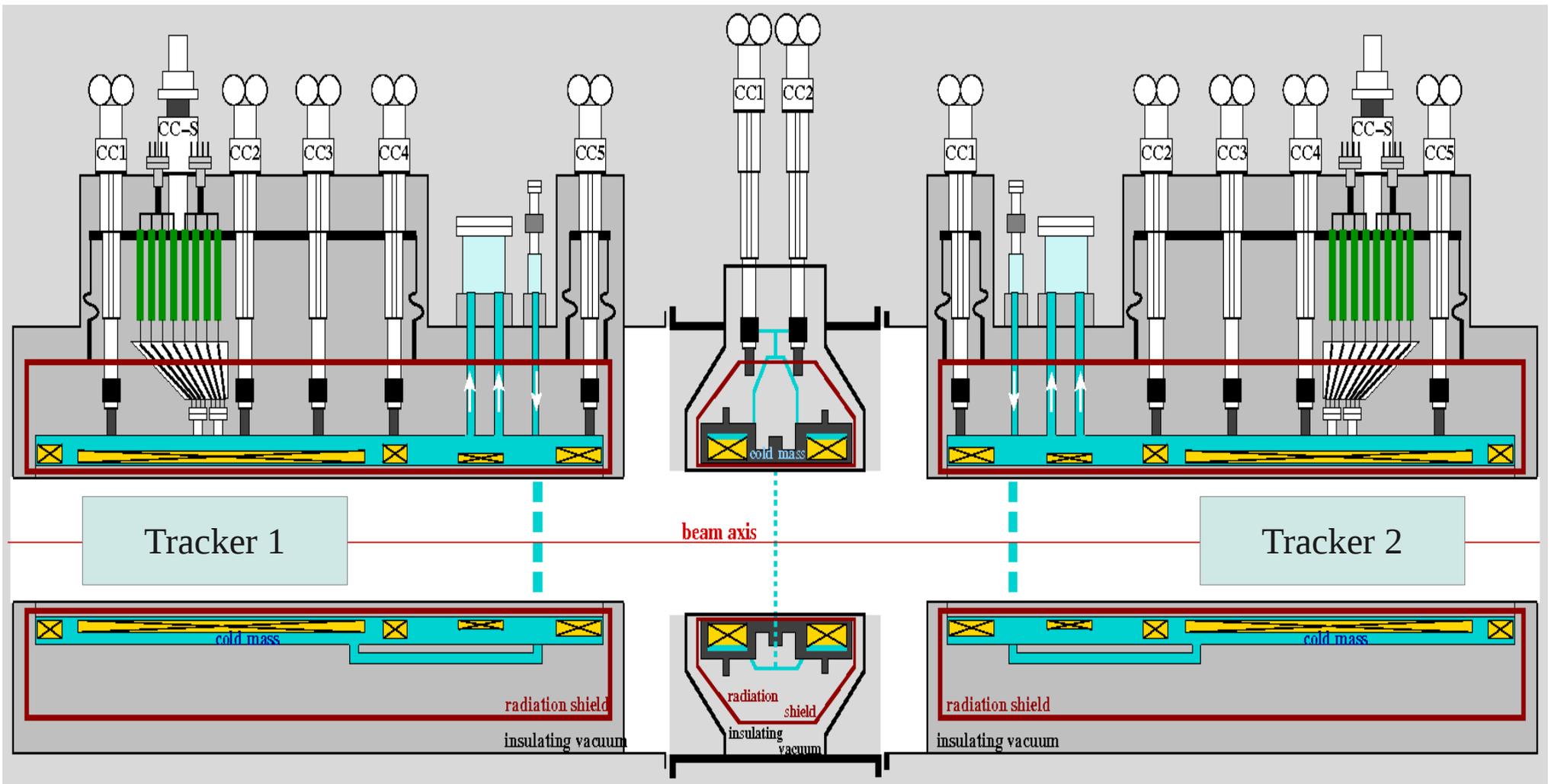
30<sup>th</sup> May 2014

# Content

- SciFi trackers and MICE
- History
- Near history
- Recent developments
- Status of systems
- The near future
- Thanks to those who did the work



- Required to measure 0.1% resolution on emittance with single particle measurements
- 350 micron fibres bundled into 7 fibre channels
- Position resolution of 470 microns
- 3 fibre planes per station, 5 stations per tracker
- Readout by VLPC operated at 9K with 80% QE
- 10PE / hit



- 4T solenoid field and multiple planes with 0.5mm resolution allow measurement of  $P_T$  and  $P_Z$

# History

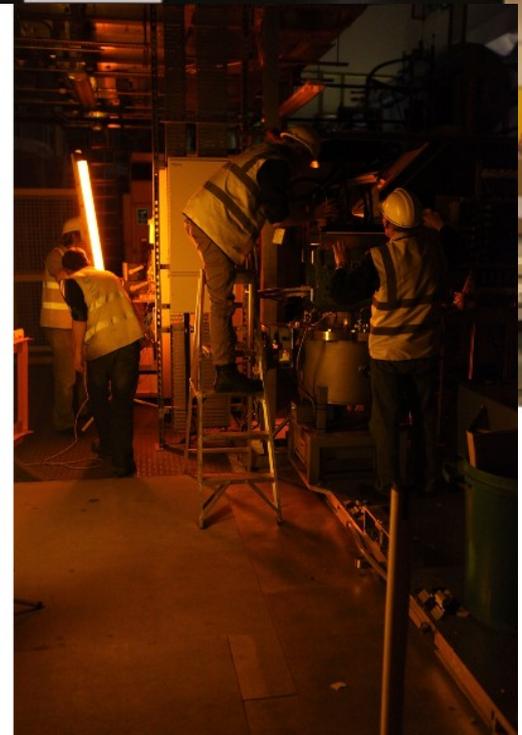
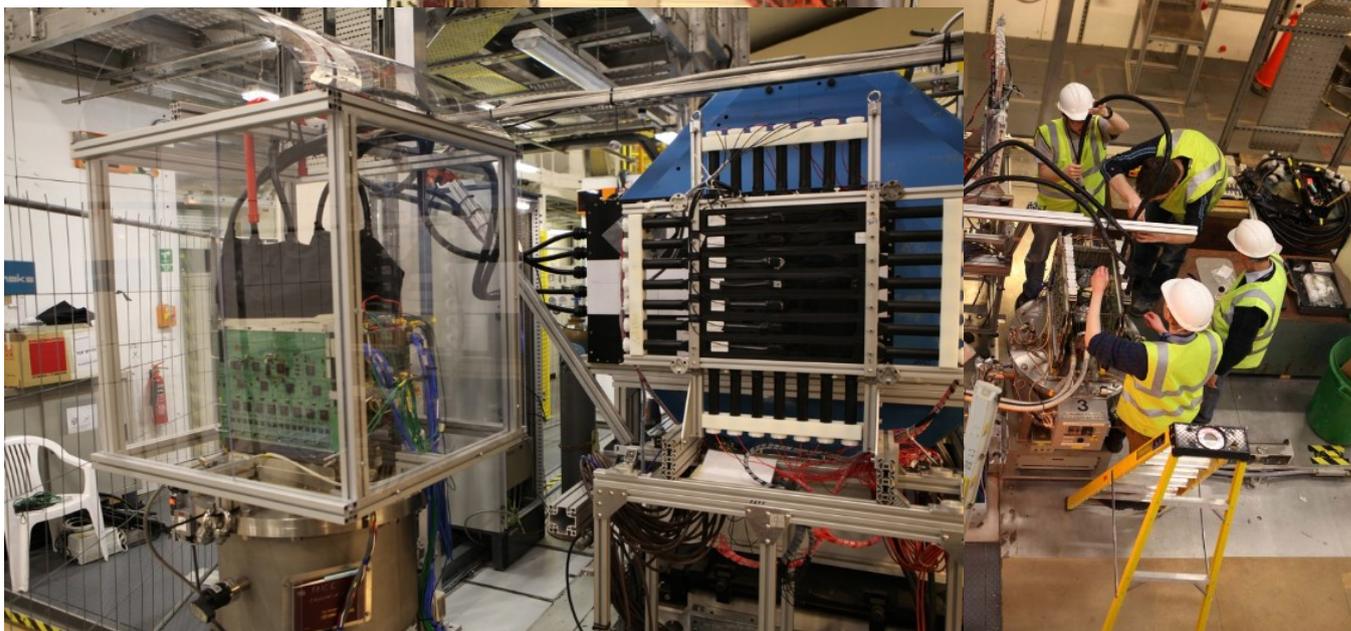
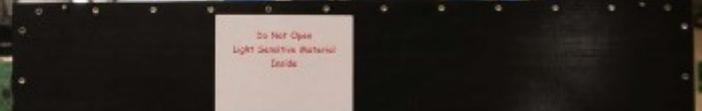
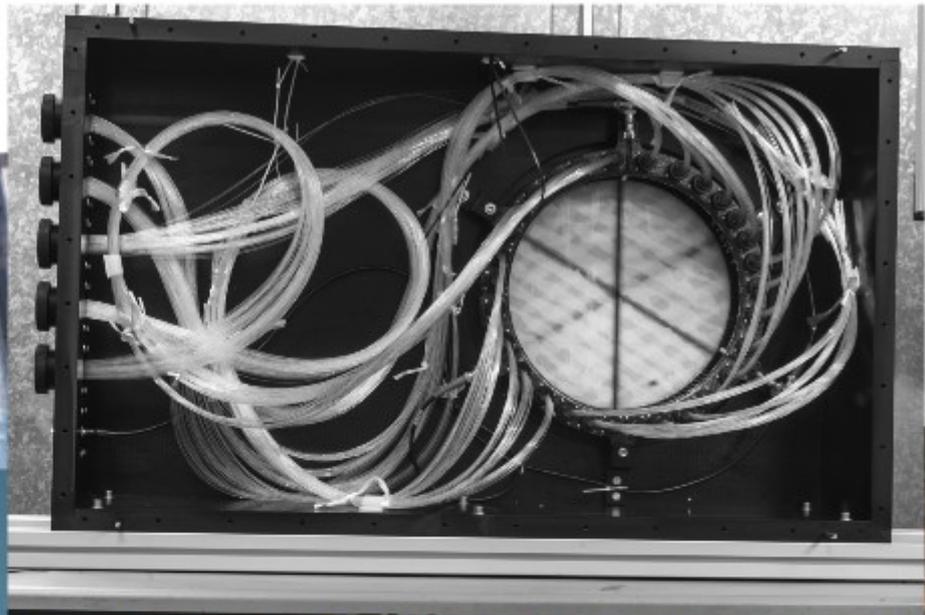
- 2008 – Tracker 1 completed and underwent cosmic testing
- 2009 – Tracker 2 completed and cosmic tests
- 2011 – NIM paper
- 2011/12 – Dual testing of trackers in realistic DAQ setup
- 2012 – Testing of single tracker module in MICE beam

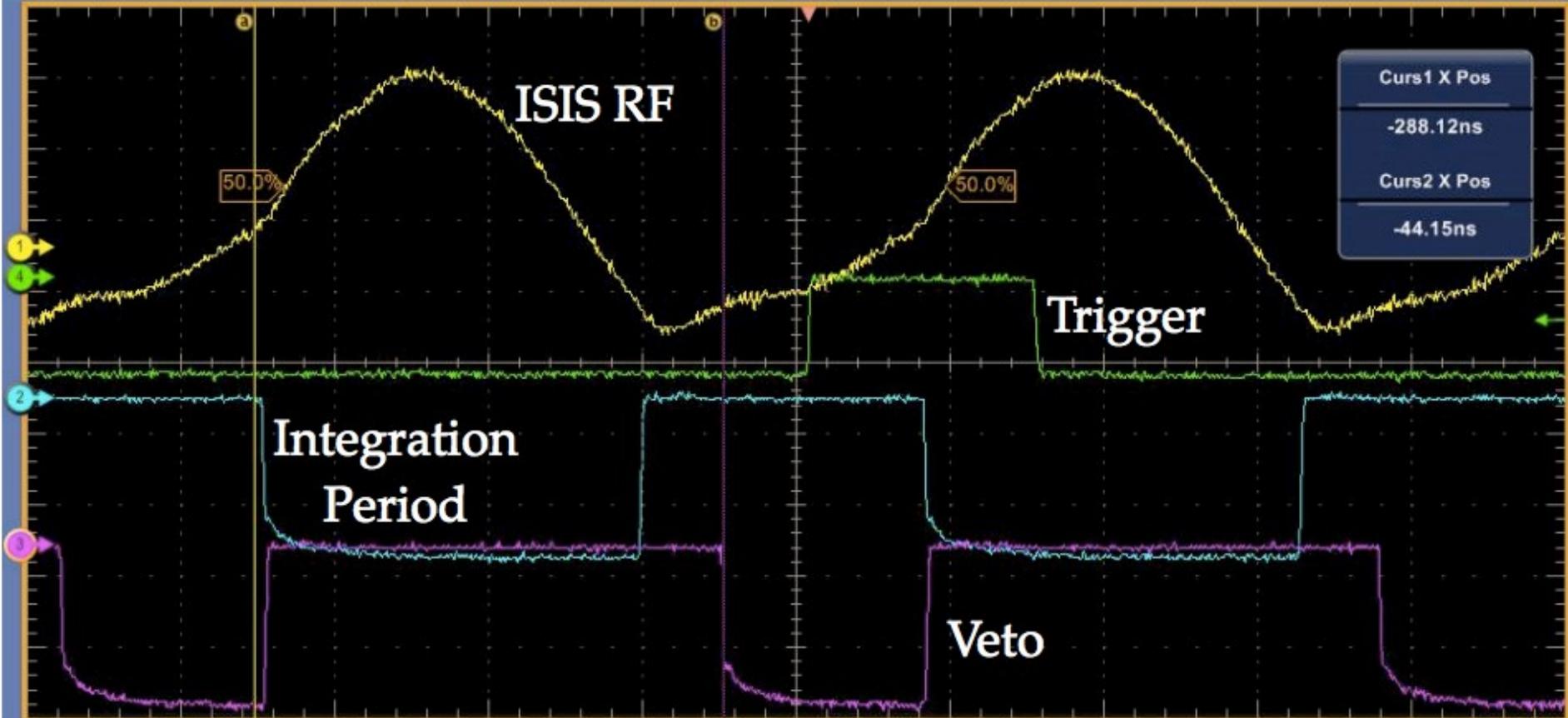
# May 2012 – Single station test

- Installation of single tracker station into MICE beamline
- Integration with full MICE DAQ
- Readout cycle aligned with ISIS spill
- Verification of timing-based efficiency
- Correlation of reconstruction with existing detectors
- Testing of online/offline software

# May 2012 Single Station Test

Effective complete test of trackers in MICE





**C1** 1.0V Offset:-12.0mV 1MΩ BW:500M  
**C2** 700mV/div 50Ω BW:1.0G  
**C3** 700mV/div 50Ω BW:1.0G  
**C4** 800mV/div 50Ω BW:1.0G

**t1** -288.12ns  
**t2** -44.153ns  
**Δt** 243.967ns  
**1/Δt** 4.099MHz

**A1** **C4**  $\int$  -480mV

80.0ns/div 1.25GS/s 800ps/pt  
 Stopped Single Seq  
 1 acqs RL:1.0k  
 Man May 16, 2012 18:30:53

	Value	Mean	Min	Max	St Dev	Count	Info
<b>C1</b> Freq*	2.909MHz	2.9086678M	2.909M	2.909M	0.0	1.0	

**Cursor Controls**

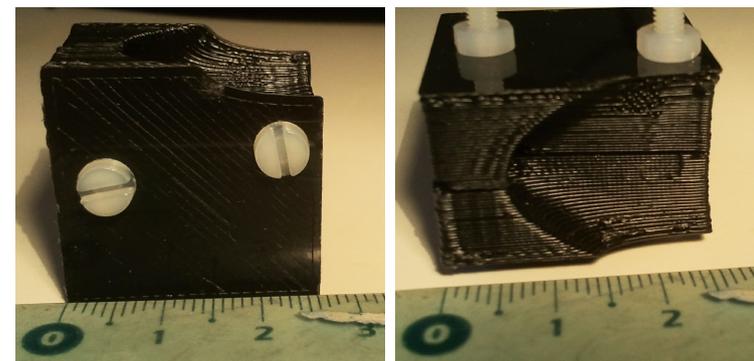
Source: Cursor 1 (Ch 1), Cursor 2 (Ch 3)

Cursor Type: H Bars, V Bars, Waveform, Screen

Move Cursors to Center

Setup

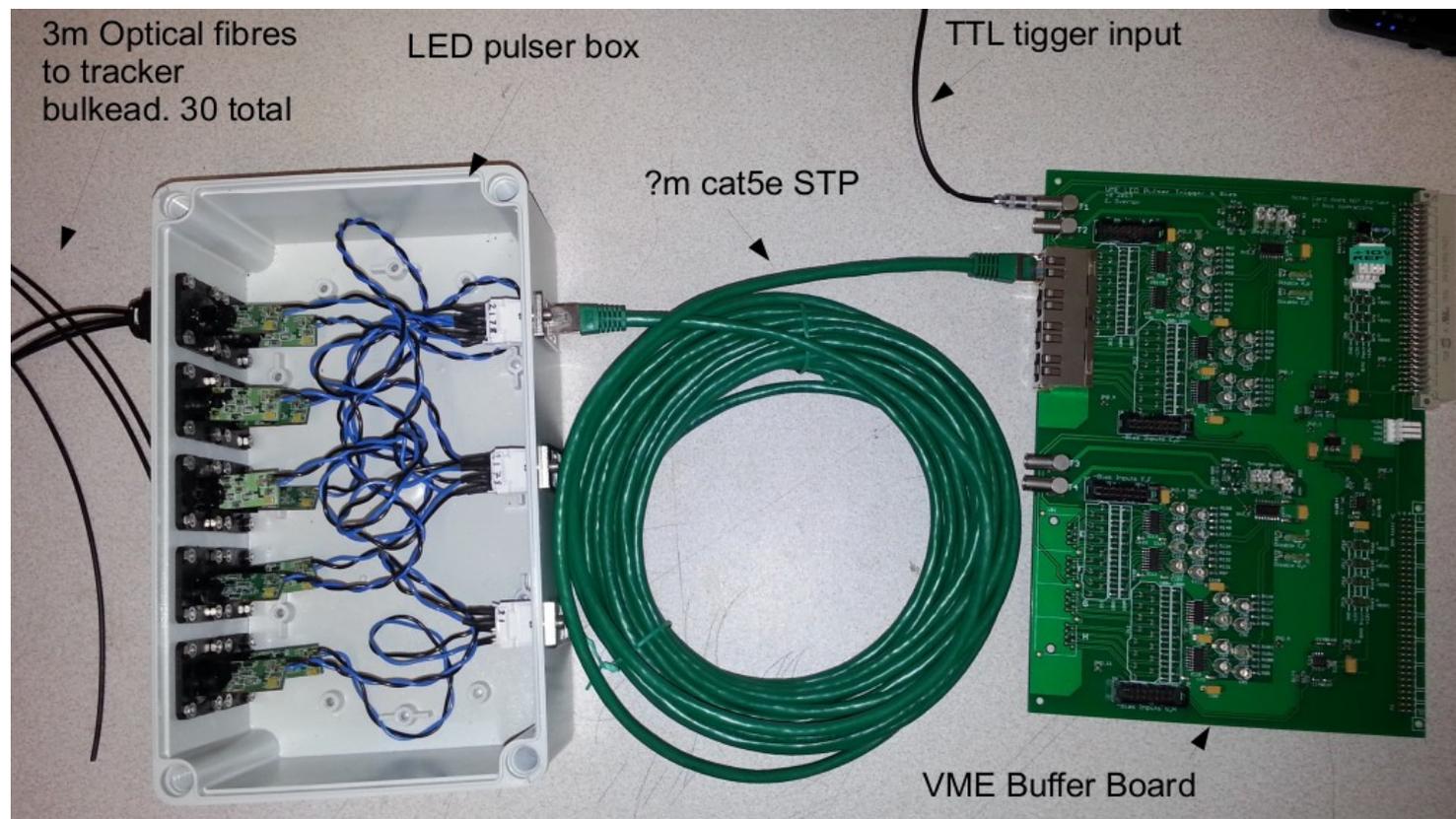
Channel	Pulse Height (mV)	FWHM Pulse Width (ns)
1	-106 ± 9	3.9 ± 0.3
2	-103 ± 9	4.0 ± 0.4
3	-103 ± 9	3.9 ± 0.3
<b>4</b>	<b>-135 ± 8</b>	<b>6.57 ± 0.3</b>
5	-101 ± 8	3.9 ± 0.3
6	-99 ± 8	3.8 ± 0.3
7	-115 ± 10	4.0 ± 0.3
8	-108 ± 9	3.9 ± 0.3
9	-92 ± 7	3.9 ± 0.3
10	-72 ± 9	3.8 ± 0.5



**Type II Modules:** When viewed from side (right image) light cone indent is much smaller (from 15mm to 26mm). Also the cone from above looks squashed or 'pointy'.

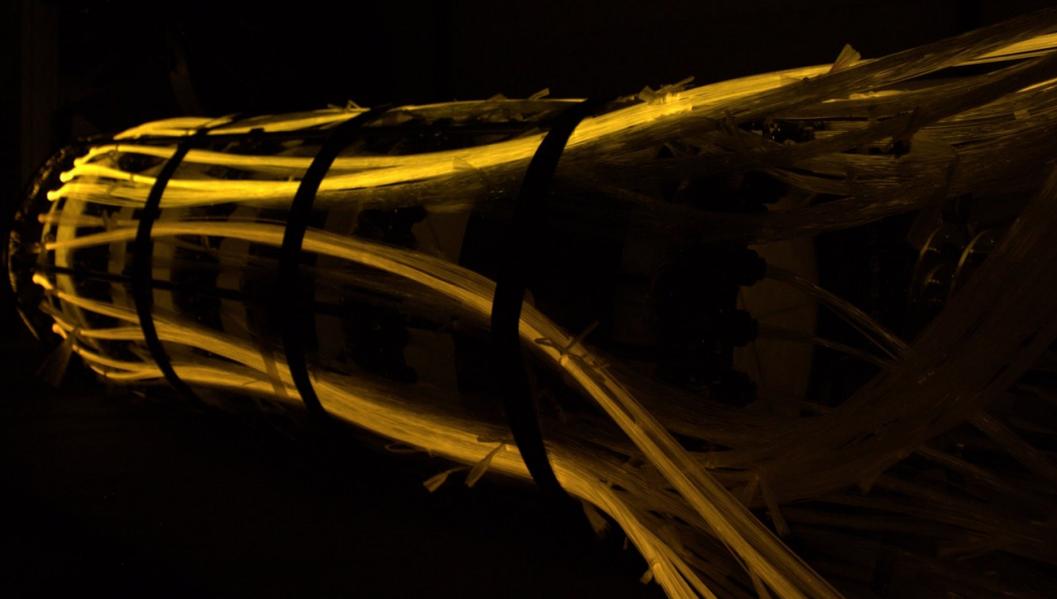
LED system installed for in-situ calibration of bias, timing, discriminators

Programmable pulse height, delay, amplitude with custom electronics



# Autumn/winter 2013 – tracker QA

- Light-tight enclosure constructed at RAL
- Internal waveguides checked for cracks/dead fibres
- Some visible light leaks, but  $< 1\%$
- LEDs installed



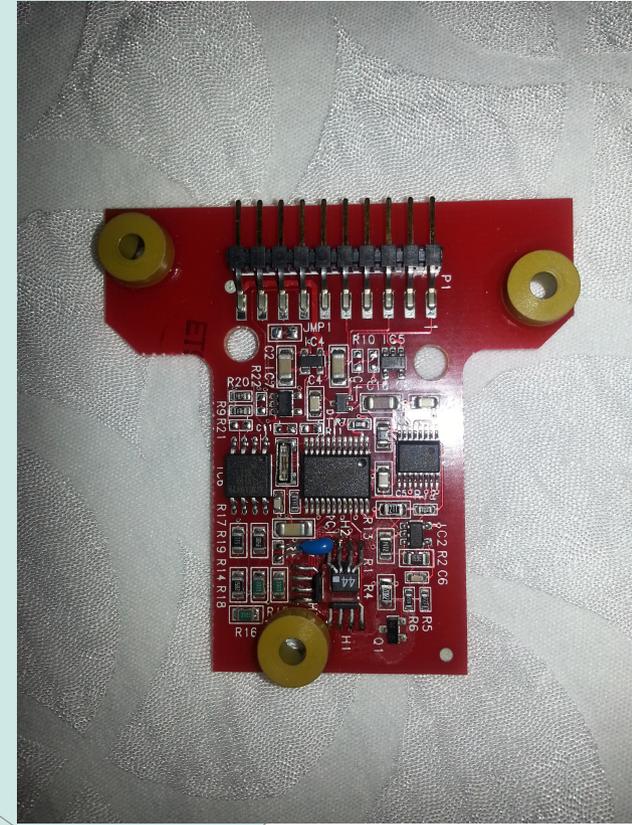
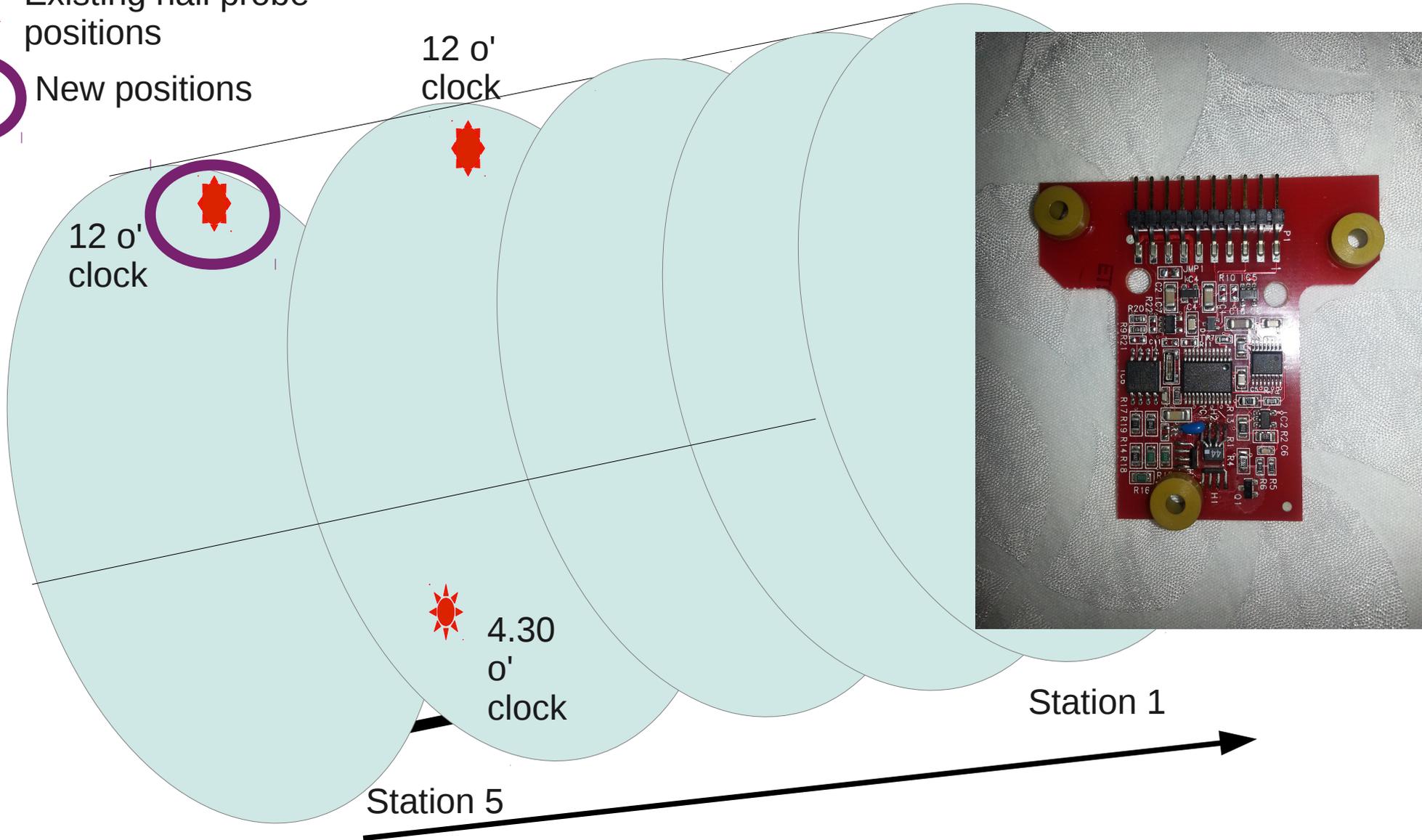
# Hall Probe Positions

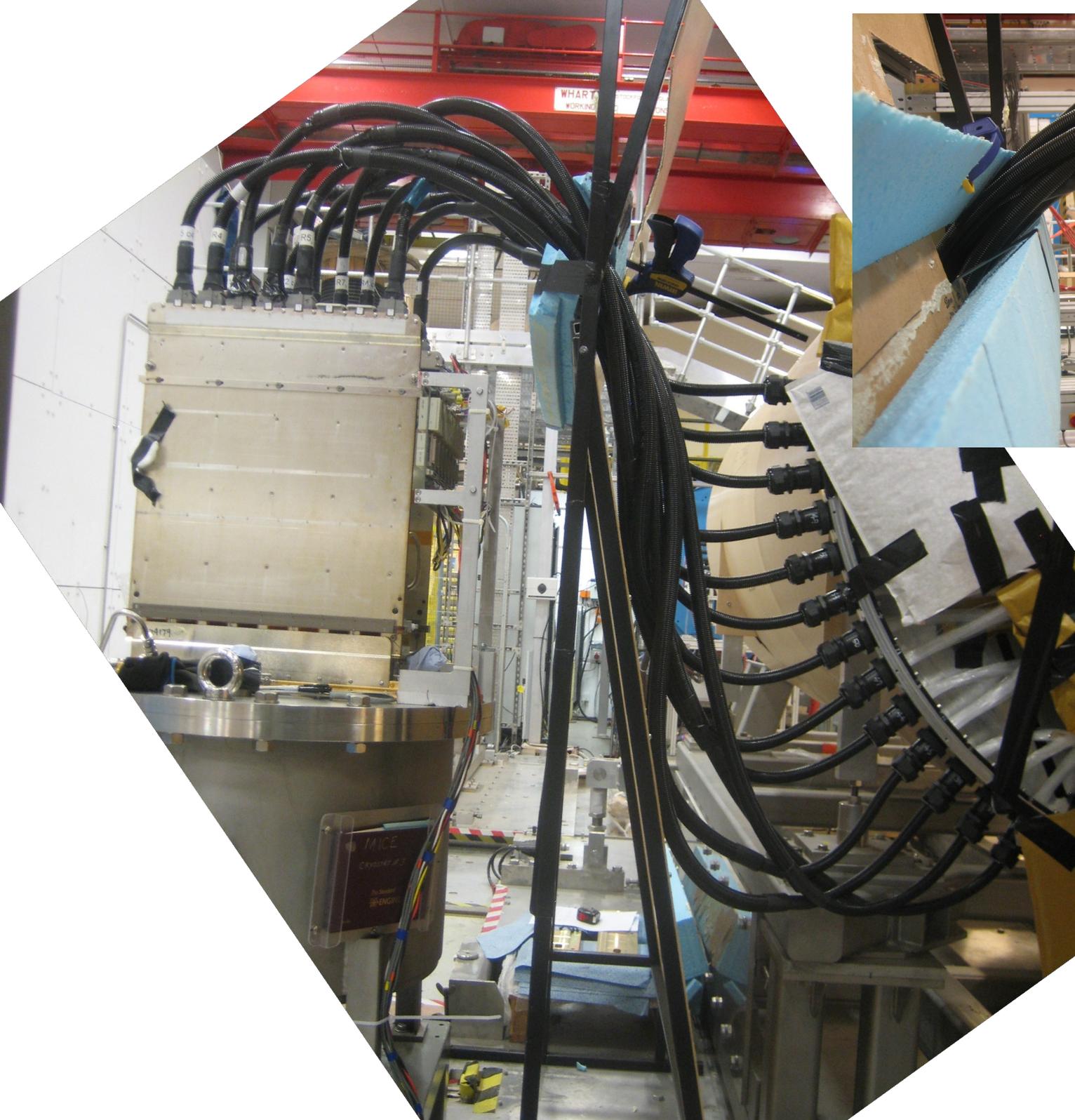


Existing hall probe positions



New positions

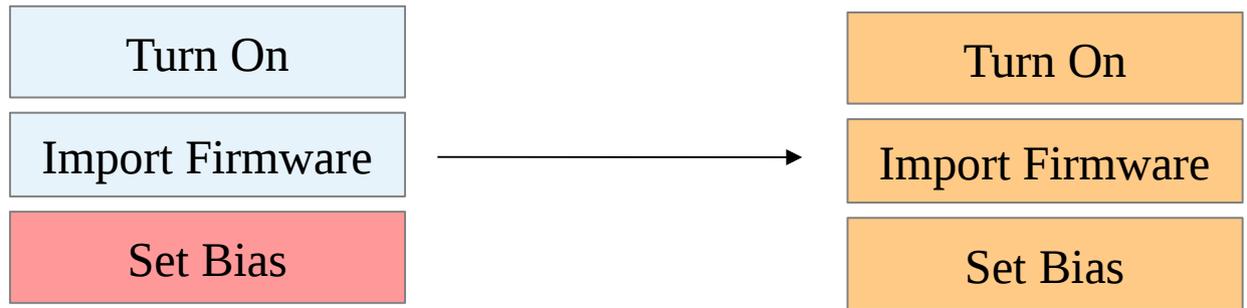




Challenges in routing waveguides from tracker to VLPC readout through partial return yoke addressed

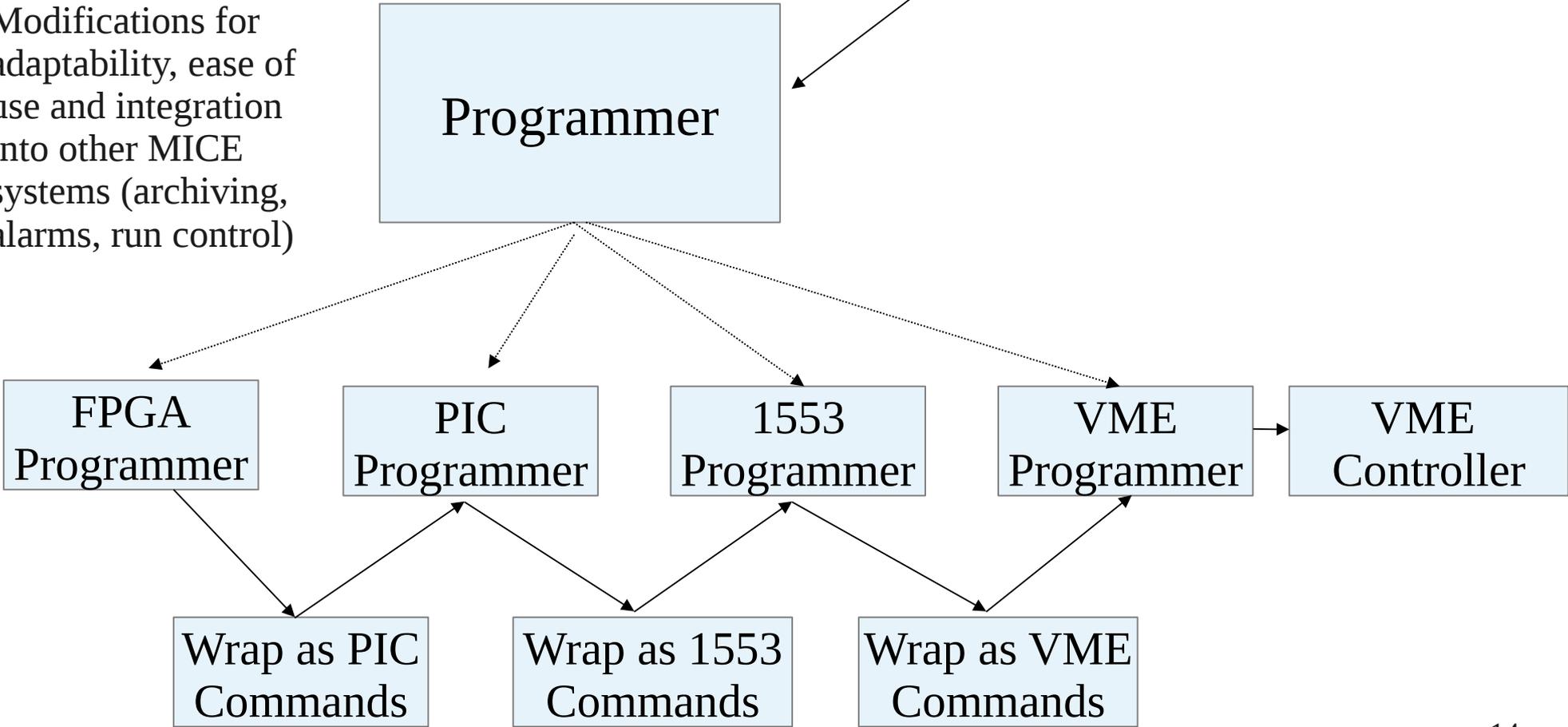
# Controls, Monitoring, DAQ

- D0 system adapted to MICE – Analogue Front End Ilt and VLSB data buffering
- VLSB custom but simple use, AFE more complicated
- Entire working system proven in single station test
- Ongoing modifications to keep up with sibling systems in MICE – C&M and DAQ
- Majority of controls work is single initialization of system – hardware is then independent
- Temperature of VLPC will be monitored and alarmed



Sub-functions broken into blocks and wrapped together into bus commands

- Controls and monitoring well defined
- Modifications for adaptability, ease of use and integration into other MICE systems (archiving, alarms, run control)

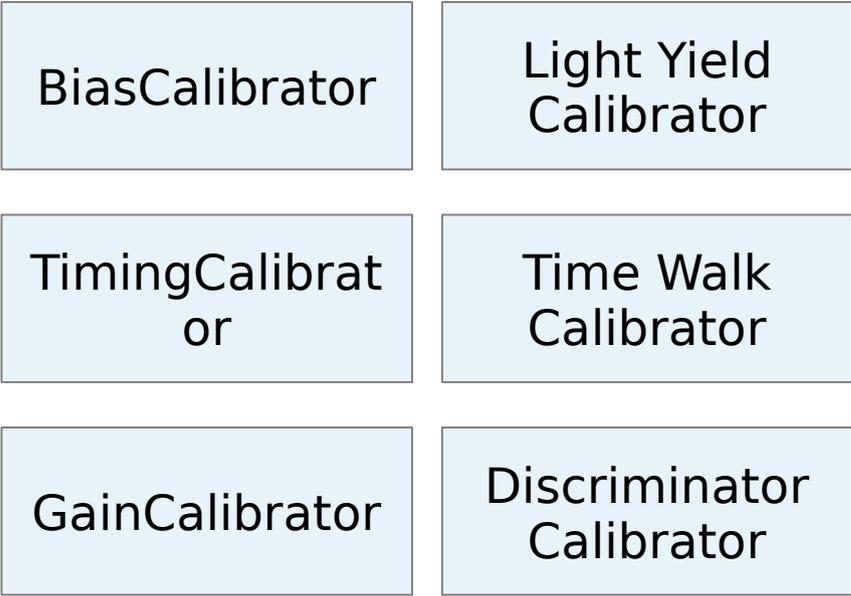


# Calibrations

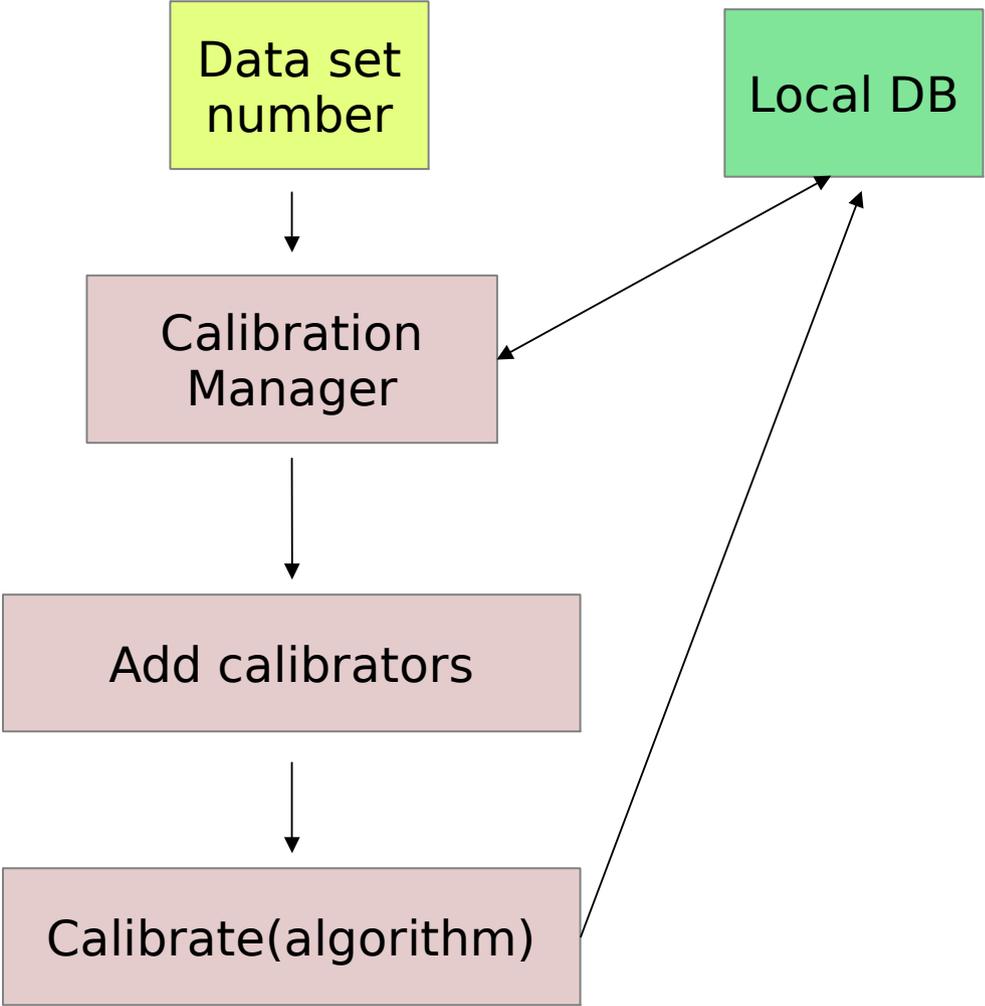
- Temperature – already well defined
- Bias – Essential, but well defined and stable – 40 data points
- Discriminators – Required for zero-suppression (at readout end). Possibly environment dependant. Source of analogue noise –  $256^2$  data points maximum, in reality  $\sim 100$
- TDCs – Required to get time information. Simple calibration. Also environment dependant and source of noise – 10 data points
- Time walk – compensate for ADC-TDC correlation – 50 data points
- Diagnostics – Take standard data and compare to accepted distributions – weekly, if fail, re-calibrate

# Calibrator

Runs on highly compressed output of “mini-DAQ”

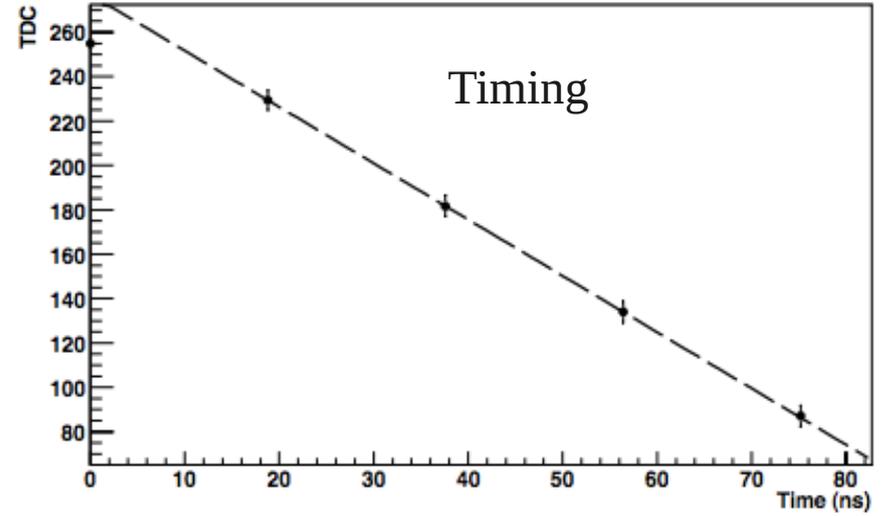
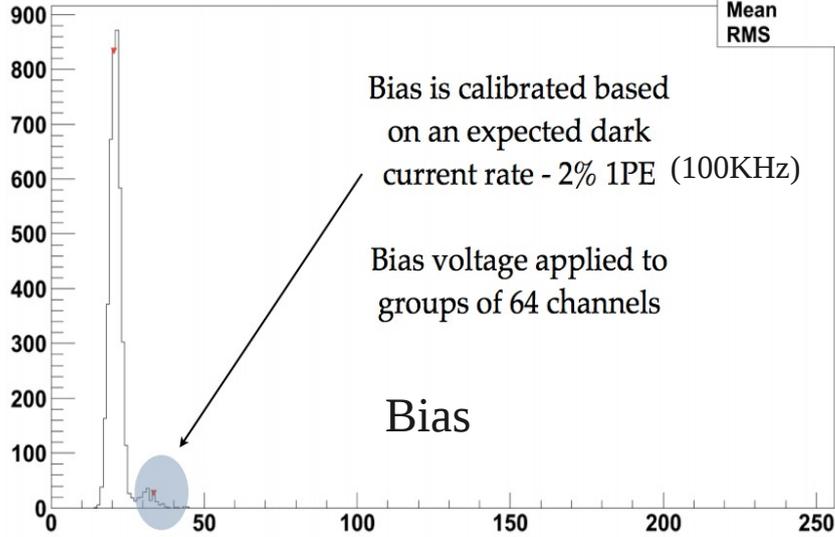


- Automated calibrations running on fast-DAQ
- Algorithms all well defined and majority tested on LED/cosmic/beam data

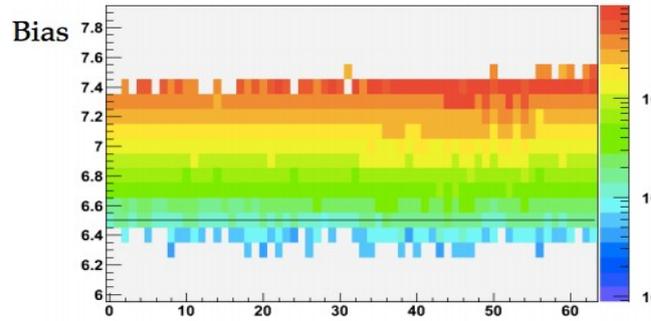


Board: 3 Bank: 3 Channel: 66

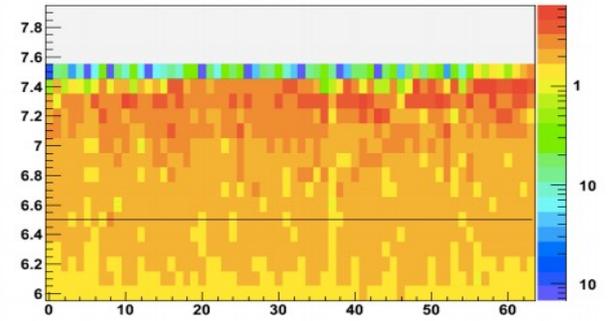
3-3-66	
Entries	4192
Mean	20.89
RMS	2.96



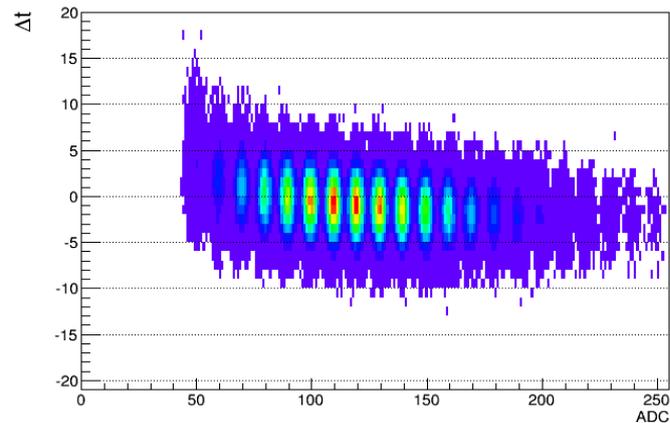
6-0-AllChannelsGraph Dark count



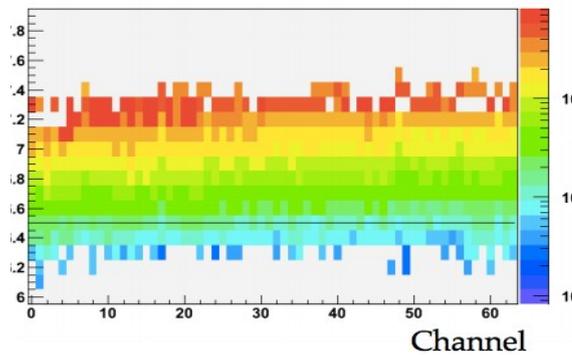
6-0-AllChannelsPE Mean PE



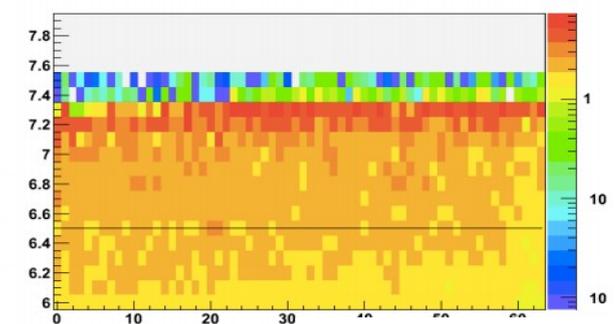
Timewalk



-AllChannelsGraph



6-1-AllChannelsPE

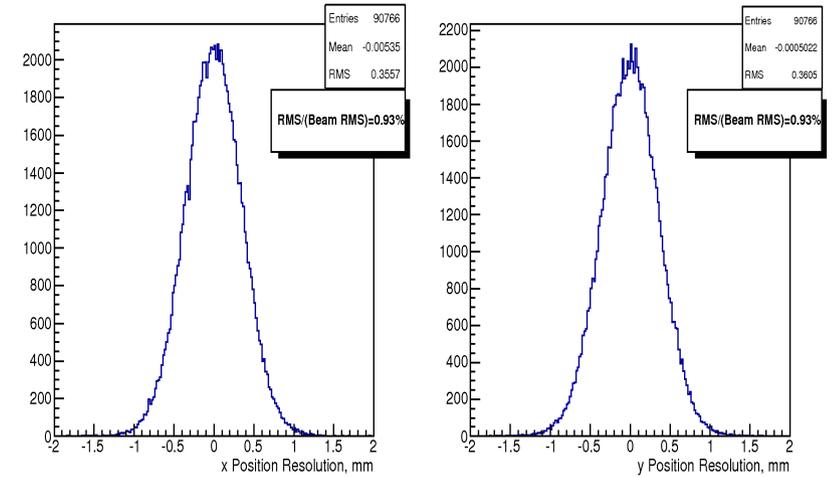
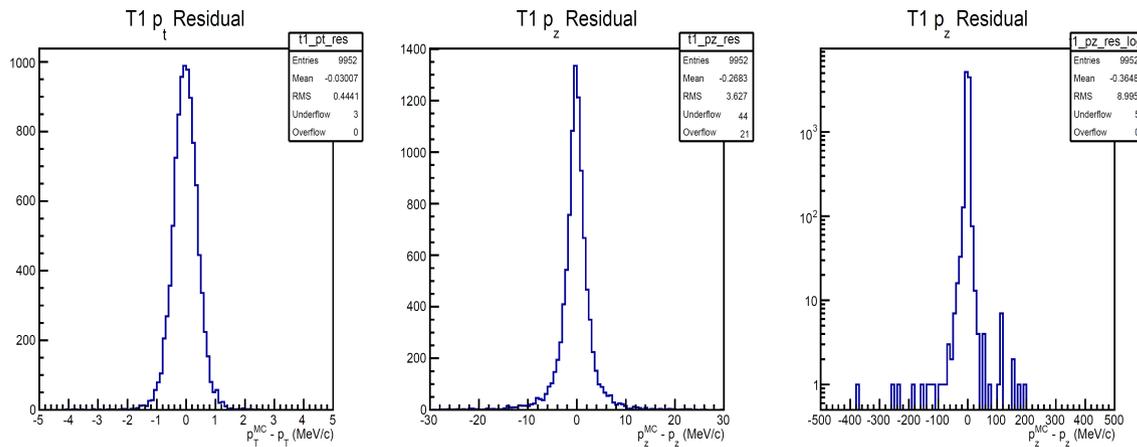


# Software

- Working with MAUS structure
- Real-data unpacking, calibration, space-point reconstruction
- Pattern recognition with and without field
- Kalman filter for fine smoothing of tracks within well modeled field
- MC with realistic beam structure and detector noise

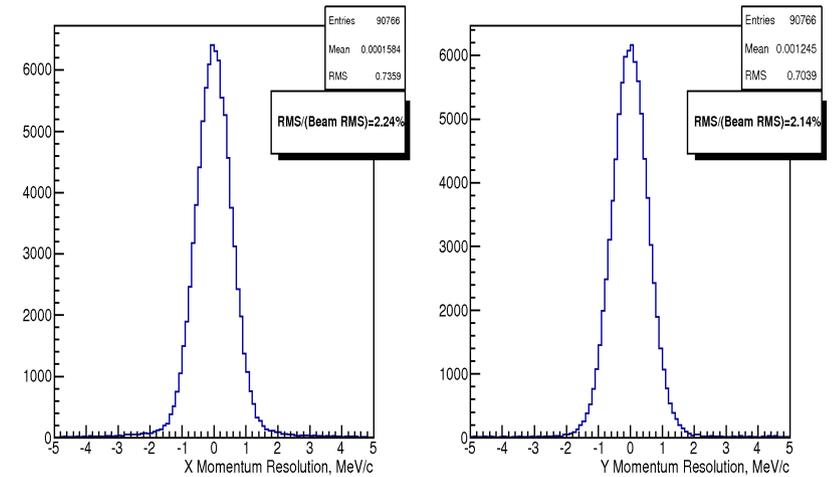
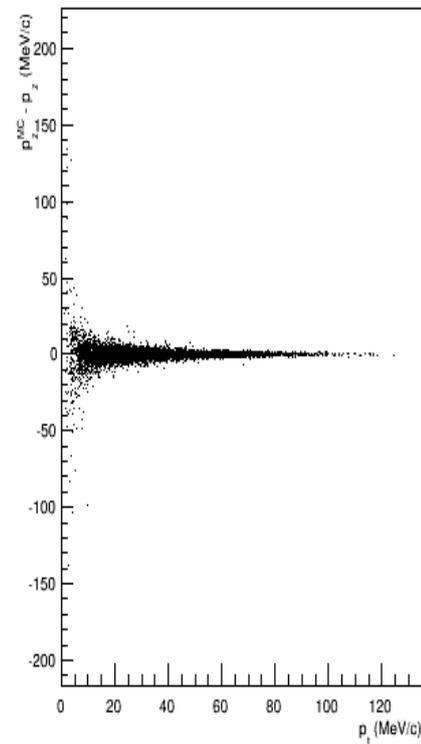
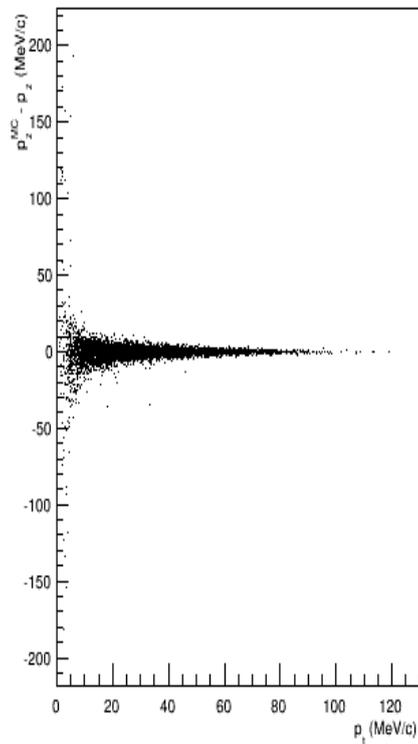
# Momentum reconstruction

Full Kalman filter – PT  
 resolution 1% of beam RMS



$T1 p_z$  res vs.  $p_t$

$T2 p_z$  res vs.  $p_t$





# Tracker 2 installed into SS2

- Tracker installed into SS2 with sub-systems
- Internal waveguides attached and routed to connector panel to external waveguides
- SS2 moved into MICE hall
- Final external connections and installation of readout systems waits on PRY completion
- Cryo systems will be checked for vacuum integrity beforehand
- Readout electronics verification also planned

ID	%	Task Name	Start	Finish	Duration	Predecessors	Resource Names	May	
								B	M
1	2%	<b>Tracker Hall Integration</b>	Thu 01/05/14	Fri 20/03/15	232 days				
2	5%	<b>Pre Installation work</b>	Mon 12/05/14	Mon 03/11/14	125 days				
3	0%	<b>General Maintenance</b>	Mon 12/05/14	Wed 14/05/14	3 days				
4	0%	Gather all Tracker equipment in lab space and do stock check	Mon 12/05/14	Wed 14/05/14	3 days				
5	0%	Get Electronics spares VME/NIM/Instruments?	Mon 12/05/14	Mon 12/05/14	1 day				
6	6%	<b>Cryostat related preparation</b>	Mon 12/05/14	Tue 08/07/14	42 days				
7	25%	Warwick QA of external waveguides	Mon 12/05/14	Fri 06/06/14	20 days				
8	0%	Gather spares for making new external waveguides	Mon 12/05/14	Fri 23/05/14	10 days				
9	0%	Quote/Book/Wait service with SHI cryogenics	Mon 12/05/14	Fri 06/06/14	20 days				
10	0%	Get new aeroquip Helium lines - 8 x 10M extra plus union and Spares?	Mon 12/05/14	Mon 12/05/14	1 day				
11	0%	Re-gas pressurise compressor with BIP Helium	Mon 12/05/14	Mon 12/05/14	1 day				
12	0%	Mend broken manual pressure valve	Mon 12/05/14	Mon 12/05/14	1 day				
13	0%	Service & clean CCG pressure sensors	Mon 12/05/14	Tue 13/05/14	2 days				
14	0%	Service compressor - New Adsorber?	Mon 09/06/14	Tue 10/06/14	2 days	9			
15	0%	Service cold heads	Mon 09/06/14	Tue 10/06/14	2 days	9			
16	0%	Connect up new SL80 turbo pump to cryostat x4	Mon 12/05/14	Mon 12/05/14	1 day				
17	0%	Mount & Connect TD400 turbo controller to Turbo x4	Tue 13/05/14	Tue 13/05/14	1 day	16			
18	0%	Lab test of cryostat vac, cooling & electronics. Need He gas & Comp	Wed 11/06/14	Tue 08/07/14	20 days	11,12,13,14			
19	0%	<b>Electronics preparation</b>	Mon 12/05/14	Tue 13/05/14	2 days				
20	0%	Buy and connect up rack smoke detector?	Mon 12/05/14	Mon 12/05/14	1 day				
21	0%	Buy another Vesda VLF250 or decide on single pipeline run?	Mon 12/05/14	Mon 12/05/14	1 day				
22	0%	Run in 4 DAQ ISIS 1RF trigger cables from MLCR to Tracker rack	Mon 12/05/14	Mon 12/05/14	1 day				
23	0%	Run in fibres between Tracker rack and Controls & DAQ computers	Mon 12/05/14	Mon 12/05/14	1 day				
24	0%	Test AFE I/O boards, upgrade firmware, check locator pins	Mon 12/05/14	Tue 13/05/14	2 days		DA		
25	0%	<b>Services preparation</b>	Mon 12/05/14	Mon 03/11/14	125 days				
26	0%	Check Tracker rack & cryo positions and design for cryo stands	Mon 12/05/14	Mon 12/05/14	1 day		JT		
27	0%	Organise Mains distribution at Tracker rack positions	Tue 13/05/14	Wed 14/05/14	2 days	26	DL		
28	0%	Lay cable trays between rack and cryo position	Tue 13/05/14	Wed 14/05/14	2 days	26	Hall		
29	0%	Arrange BIP grade Helium gas line to Tracker rack	Tue 13/05/14	Tue 13/05/14	1 day	26	Hall		
30	0%	Global vac pipework in place end June 2014	Mon 30/06/14	Mon 30/06/14	0 days		MT		
31	0%	DL vac controls rack & software (NW corner) in place around Nov 2014	Mon 03/11/14	Mon 03/11/14	0 days		DL		
32	0%	<b>Make LED Calibration boxes</b>	Mon 12/05/14	Mon 19/05/14	6 days				
33	0%	Construct 2nd LED box (Drill box, pot fibres & PCB and Solder)	Mon 12/05/14	Tue 13/05/14	2 days				

Project: MICE HALL INSTALLATION S  
Date: Wed 14/05/14

	Inactive Milestone		Inactive Summary		Manual Summary
	Start-only		Finish-only		Manual Summary Rollup
	Manual Task		Duration-only		Inactive Task

